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Semi-Annual Status Report

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"Selection of Behavioral Tasks & Development of  
Software for Evaluation of Rhesus Monkey  
Behavior During Spaceflight"

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Behavior & Performance Project

I. SUMMARY OF FINDINGS: During this semiannual period, we reported the results of earlier experiments in several publications and presentations. It is important to demonstrate in the literature these areas of human-monkey continuity and discontinuity. Thus, each of these reports serves to support the animal model of behavior and performance research. In addition, we discussed educational applications of the PTS at the Life Sciences and Space Medicine Conference and Exhibition. These spin-offs of the PTS system with human adults and children--including children with mental retardation--promise to expand the usefulness of the tasks and hardware

1. Washburn, D. A., Sevcik, R. A., Rumbaugh, D. M., & Ronski, M. A. (1996). Educational applications of the Psychomotor Test System. Proceedings of the AIAA Life Sciences and Space Medicine Conference and Exhibit.

The Psychomotor Test System (PTS; also known by the name of its prototype, the Language Research Center's Computerized Test System) was designed to provide measures of performance on a battery of psychological tasks. At a hardware level, the PTS consists of rather common technology: A DOS-based desktop computer with VGA color graphics, a game card and joystick, and an interface with an external reward device. The software is also fairly ordinary, at least by contemporary computer game standards: Manipulation of the joystick results in corresponding movements of a cursor on the screen, which can in turn be brought into contact with one or more computer-graphic stimuli. Notwithstanding, we will argue that the PTS is quite singular and innovative--not because of technological invention, but because of the effective application of these common resources to new and challenging problems.

The PTS was developed as part of an international, inter-disciplinary research program to study how rhesus monkeys adapt behaviorally and physiologically to spaceflight. The test system was designed to address two primary needs: (a) the need to understand the effects of spaceflight on psychomotor function, learning, memory, attention, perception, problem solving, and other psychological processes; and (b) the need to support the psychological well-being of nonhuman primates maintained for integrated physiological research both on the ground and in spaceflight research. Despite a substantial literature suggesting that rhesus monkeys would fail to learn to use a joystick-driven computer test system like the PTS, we developed a curriculum of tasks and a training protocol that has been highly successful in producing a pool of highly skilled, flight-ready research animals. We have also reported that the PTS is effective for addressing the two primary needs that sparked its development (although the opportunity to use the PTS in spaceflight research remains in the future).

Finally, we have witnessed numerous Earth-bound applications of and benefits from this curriculum of tasks and the PTS training procedures. Several of these spin-offs were described in previous reports. For example, the PTS has proven to be a remarkably effective tool for comparative psychological research. Many primate species have been trained and tested with the system, and their data have illuminated the continuities in psychological processes among monkeys, apes, and humans.

Rhesus monkeys work readily on PTS tasks, and will choose to engage in task-directed behavior even when other preferred activities are available. Task performance provides challenge and control to the monkeys, and promotes physical health and adaptive behavior. These findings indicate that the PTS is effective as a means of providing environmental enrichment and supporting the psychological well-being of research animals.

In the present report, we will describe the educational applications of the PTS. For instances, many of the tasks of the PTS have been modified for pedagogical use in college courses. Students respond to these tasks using hardware and software similar to that used with the monkeys. Laboratory courses that cover topics such as animal behavior, cognition, human factors, learning, and biopsychology benefit from the availability of the PTS tasks. By performing the tasks, students have learned principles of research design, discovered the similarities and differences between species, and experienced many of the central findings in psychology. Additionally, the tasks provide a perfect catalyst for discussing NASA's space life sciences research and the challenges that accompany spaceflight experimentation.

Even more pronounced benefits have been realized in the application of PTS tasks and training procedures in classrooms for youths with mental retardation. Oral language deficits frequently impede research and testing of these students. Similarly, many aspects of traditional education are difficult to apply to children and teens with impaired language ability. PTS tasks provide the means systematically to train and to assess many of these skills and concepts using nonverbal procedures that are proven to be effective. For example, students with mental retardation have developed the psychomotor skills necessary to manipulate a joystick so as to control the movements of a computer-generated cursor. It is significant that this training was successful despite the fact that it was self-administered, self-paced, and unreinforced by tangible rewards. The students worked ad libitum with little or no teacher supervision or intervention.

Educational applications of the PTS for youths with mental retardation promise to result in qualitative changes as well as these changes in degree. PTS training promotes "learning how to learn." Based on previous findings, we anticipate that structured exposure to PTS tasks will result in shifts in the nature of learning by these youths--from primarily associative to relational or rule-like. Students who develop through PTS training the capacity for relational learning will gain access to many new avenues for education.

Many applications of the PTS for education exist. Taken together with other spin-offs afforded by the training procedure and tasks, it is clear that uncommon benefits have been gleaned from the creative application of this NASA-supported technology to new problems and questions. [Research supported by NASA NAG2-438 and NIH HD-06016.]

2. Fillion, C. M., Washburn, D. A., & Gullledge, J. P. (In press). Can monkeys (Macaca mulatta) respond to invisible displacements? Journal of Comparative Psychology.

#### Abstract

Four experiments were conducted to assess whether or not rhesus macaques could infer the existence and movement of an unperceived stimulus. Subjects were tested with two computerized tasks that required them to chase or to "shoot at" a moving target that either remained visible or became invisible for a portion of its path of movement. Response patterns were analyzed and compared between target-visible and target-invisible conditions. Results suggest the monkeys were capable of inferring the existence and movement of an unperceived stimulus. Results are discussed in terms of Piaget's and Inhelder's theory on reproductive and anticipatory representation and in terms of the unique learning experience

that the computerized testing paradigm affords.

3. Shields, W. E., Smith, J. D., & Washburn, D. A. (In press). Uncertain responses by humans and rhesus monkeys in a psychophysical Same-Different task. Journal of Experimental Psychology: General.

#### Abstract

Rhesus monkeys (Macaca mulatta) use an uncertain response adaptively to escape threshold trials in a psychophysical same-different task, even while operating simultaneously at many absolute stimulus levels and levels of difficulty. These uncertainty behaviors defeat a variety of associative interpretations. They reveal the cognitive sophistication that animals bring to their behavioral regulation in uncertain situations, and underscore the similarity between humans' and animals' uncertain responses.

4. Washburn, D. A., & Astur, R. S. (In press). Comparative investigations of visuospatial memory: Rehearsal in the sketchpad? Memory and Cognition.

#### Abstract

Investigations of working memory tend to focus on the retention of verbal information. The present experiments were designed to characterize the active maintenance rehearsal process used in the retention of visuospatial information. Rhesus monkeys (Macaca mulatta;  $N = 6$ ) were tested as well as humans (total  $N = 90$ ) because the nonhuman primates have excellent visual working memory but, unlike humans, cannot verbally recode the stimuli so as to employ verbal rehearsal mechanisms. A series of experiments was conducted using a distractor-task paradigm, a directed forgetting procedure, and a dual-task paradigm. No evidence was found for an active maintenance process for either species. Rather, it appears that information is maintained in the visuospatial sketchpad without active rehearsal.

5. Gullledge, J. P., & Washburn, D. A. (1996, April). Rhesus monkeys' reviews of video reinforcement: Two thumbs down. Paper presented at the meeting of the Southern Society for Philosophy and Psychology, Nashville, TN.

#### Abstract

Two rhesus monkeys (Macaca mulatta) were tested to determine the effectiveness of video reinforcement to sustain performance. The monkeys were permitted to choose from a menu whether they would work for pellets alone or for pellets+video. The monkeys significantly preferred to receive pellet rewards followed by 10 s with a blank screen rather than pellets plus 10 s of video. When the monkeys chose to watch video, however, they reliably chose to watch video of themselves (i.e., Abel watched video of Abel, Baker of Baker). Although video appears to offer little general value as a reinforcement tool, its continued use is commended by the implications for self- or face-recognition research.

## II Bion 11 Training

PTS training. With the cooperation of IMBP personnel, we have trained 24 young monkeys to perform our battery of joystick-based PTS tasks. David Washburn, John Gullledge, and Jane Patton have made several extended visits to Moscow to support this training. The remaining pool of flight candidates are highly skilled on the tasks necessary for pre- and post-flight tests.

Locomotion training. We have worked with investigators from the muscle discipline to understand the goals for their pre- and post-flight locomotion training. John Gullledge and Jane Patton have treadmill-trained monkeys in Moscow, following the procedures developed at the Sonny Carter Life Sciences Laboratory in Atlanta. The monkeys that remain in the flight pool in Moscow are experienced at paced locomotion on the treadmill and appear to be ready for the flight experiment.

## III Bion 11 Flight Science

Tasks. We have modified the PTS software to permit collection and analysis of pre- and post-flight data. The current task was implemented onto test stations at IMBP.

Psychological well-being questionnaire. A checklist was produced and implemented to permit daily pre- and post-flight assessment of psychological well-being. The checklist is currently being used in Moscow to provide data against which post-flight fitness will be compared, and to which PTS data will be correlated.

Pre-flight metabolic test. The primary pre-flight data for our flight science were collected during testing of flight monkeys in metabolic caging at IMBP. Jane Patton from the Sonny Carter Life Sciences Laboratory was present to support the first of this series of tests.

Meetings. In April, 1996, we participated in the Bion IWG in Moscow. On May 29 to June 5, 1996, we hosted Dr. Shlyk, Dr. Vasilyeva, and Ms. Tverskaya at the Sonny Carter Life Sciences Laboratory. We discussed training schedules and criteria, and signed agreement based on these meetings.

## IV Ongoing research

Several lines of research continue at the Sonny Carter Life Sciences Laboratory. We are testing new research paradigms for measuring memory and attention in humans and adults. We are conducting the latest experiments in the series to elucidate psychological well-being and its indications. We also continue to analyze and report the results of prior experiments (including the ARRT test).